

AERODYNAMIC CHARACTERISTICS OF MIRA FASTBACK MODEL IN EXPERIMENT AND CFD

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ABSTRACT—The lasting high fuel cost has recently inspired the resurgence in drag reduction research for vehicles, which calls for a thorough understanding of the vehicle wake. The acknowledged MIRA fastback vehicle model is characterized by similar real vehicle geometry, thus it is especially suitable for the above purpose. In spite of a considerable number of previous investigations, our knowledge of flow around this model remains incomplete. This paper aims to visit turbulent flow structure behind this model. An investigation has been conducted to measure the near wake flow structure of the MIRA 1/8 scale model, using both Particle Image Velocimetry (PIV) experimental method and Computational Fluid Dynamics (CFD) simulation method. In order to capture the flow structure accurately, PIV measurement was performed in different sections along three orthogonal directions, and the CFD method acquired additional simulation results to catch the better flow status. Through the maps of the time-averaged vorticity, the instantaneous vorticity and the handled velocity vector from the PIV and CFD methods, we found out the formation mechanism of the transient flow of fastback model and summed up the schematic of flow structure. This study not only analyzed the vortex shedding characteristics of turbulent near wake, but more importantly provided insight into the complex three-dimensional features of the flow structure in the wakes of MIRA fastback model.

KEY WORDS : Flow structures, MIRA fastback model, PIV, CFD

1. INTRODUCTION

The global warming and lasting high fuel costs in the few years highlight the necessity and urgency of drag reduction research for vehicles, which warrants a thorough understanding of flow around vehicles because of a connection between the flow structure and aerodynamics drag. Past studies have unveiled that the pressure drag contributes predominately to the total drag acting on vehicles, particularly in high speed (Fu, 1996). The pressure drag is generated largely by the after-body for most cars, with little contribution from the fore-body (Hucho and Sovran, 1993), which is directly linked to the coherent structures in the vehicle wake (Beaudoin and Aider, 2008). As such, the wake of three-dimensional (3-D) vehicle models has caught considerable attention in the past because of its fundamental and engineering significance (Oertel, 1990), a large number of experimental and numerical investigations have been performed since the pioneer work of Janssen and Hucho (1975).

Ahmed model (Ahmed *et al.*, 1984) is perhaps the most widely studied simplified car model, which is a 3-D bluff body. This flow structure is unsteady and very complicated and highly 3-D, including three major components: a recirculation bubble over the rear slanted surface, longitudinal vortices originating from the two side edge or

C-pillars of the surface, and a recirculation torus in the base of the model (Conan *et al.*, 2005; Krajnovic and Davidson, 2005; Vio *et al.*, 2005; Gilliéron *et al.*, 2010; Thacker *et al.*, 2012, 2013). The strength and behaviors of the three types of coherent structures and their interactions depend on the slant angle of the upper rear surface of model (Ahmed *et al.*, 1984). Fu and Liu (1996) carried out the flow visualization, force measuring, distribution of pressure and velocity experiments to the fastback model in the wind tunnel, the research showed that the wake included a pair of longitudinal vortices. Despite the limitations on computing power and cell capability, it was optimistic that numerical methods could be set to predict flow around vehicle shapes by the simulation results. N. Kang (Kang and Qiao, 2003) studied the flow around the fastback model using STAR-CD, which showed that the flow structure was characterized by separation flow in the slant surface and two pair of longitudinal vortices. Our knowledge of the instantaneous and fluctuating flow fields has yet to be improved, in particular, the higher order statistical moments of fluctuating velocities such as the Reynolds stresses. This knowledge is important for a thorough understanding and control of vehicle aerodynamics. Bearman (1997) and Bearman *et al.* (1988) measured the wake of a 1/8 scale fastback vehicle and noted a significant difference between time-averaged and unsteady flow structures behind the model using PIV. The results showed that the instantaneous flow consisted of a

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